ISSN 1808-8546 (ONLINE) 1808-3765 (CD-ROM)

INITIAL GROWTH OF FORAGE CACTUS VARIETIES UNDER DIFFERENT WATER SALINITY LEVELS

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1 ABSTRACT

This study aimed to evaluate the effect of different water salinity levels in the development of two varieties of cactus pear (*Opuntia* and *Nopalea*). The spineless cactus is native from Mexico, but nowadays can be found in many places throughout the world. The experiment was performed at the Federal Institute of Ceará – IFCE/*Campus* Sobral. The experimental design was a randomized factorial 5 x 2, with five levels of salinity in irrigation water (0.0; 5.0; 10; 15 and 20 dS m^{-1}) and two varieties of cactus pear Small or sweet (*Nopalea cochenillifera* Salm-Dick) and 'elephant ear' (*Opuntia spp*) with four replications. The variables studied were plant height (cm), length and circumference of the paddle (cm), cladode thickness (cm) fresh weight (g) and dry weight (g). The variety "elephants' ear" is more suitable for cultivation under irrigation with saline water, because it presented a better vegetative performance compared to the small variety, being more tolerant to saline stress in different levels of salinity. The effect of the interaction between salinity and varieties showed a decrease in all variables analyzed, with reduction in forage development of palm varieties for higher salinity levels.

Keywords: *Opuntia spp* L., irrigation, biomass, semiarid northeastern.

SILVA, C. C.; MENEZES, A. S.; ARAGÃO, M. F.; PINHEIRO NETO, L. G.; MOREIRA, F. J. C.; SAMPAIO, G. M.
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2 RESUMO

O objetivo desse trabalho foi avaliar os níveis da salinidade da água de irrigação no crescimento de variedades de palma forrageira (*Opuntia* e *Nopalea*). A palma é natural do México, mas atualmente pode ser encontrada em várias partes do mundo. O experimento foi conduzido no Instituto Federal do Ceará – IFCE/*Campus* Sobral. O delineamento experimental foi inteiramente casualizado, no arranjo fatorial de 5 x 2, sendo cinco níveis de salinidade na água

Recebido em 22/05/2019 e aprovado para publicação em 06/01/2021
DOI: http://dx.doi.org/10.15809/irriga.2021v26n1p55-64

de irrigação (0,0; 5,0; 10; 15 e 20 dS m^{-1}) e duas variedades de palma forrageira miúda ou doce (*Nopalea cochenillifera* Salm-Dick) e a orelha de elefante (*Opuntia ssp*) com quatro repetições. As variáveis analisadas foram: a altura de planta (cm), o comprimento da raquete (cm), a circunferência (cm) e a espessura do cladódio (cm), massa fresca (g) e massa seca (g) da planta. A variedade 'orelha de elefante' é mais tolerante ao cultivo sob irrigação com água salina, pois apresentou um melhor desempenho vegetativo comparado a variedade 'miúda', sendo mais adaptada ao estresse salino nas condições de diferentes níveis de salinidade. O efeito da interação entre salinidade e variedades, ocasionou decréscimo em todas as variáveis analisadas, quanto mais elevado os níveis de salinidade, menor foi o desenvolvimento das variedades de palma forrageira.

Palavras-chave: *Opuntia ssp* L., irrigação, biomassa, semiárido nordestino.

3 INTRODUCTION

Forage palm (*Opuntia cochenillifera*) is native to Mexico, but can be found in many regions of the world, being cultivated in South America, Africa and Europe (SOUZA et al., 2008; FERRAZ et al., 2017).

The sweet or small palm (*Nopalea cochenillifera*) has small plants and a branched stem. Its cladode weighs about 350 g, is approximately 25 cm long, ovate form and bright green intense color. The flowers are red; the corolla remains half closed during the cycle (SÁ et al., 2018). The fruit is purple. Its production of green mass is lower in relation to other varieties; however, it presents similar values of dry mass and lower drought tolerance although it is resistant to insect carmine cochineal (*Dactylopius opuntiae*) (NEVES et al., 2010).

The 'elephant ear' variety is less demanding on soil fertility; however, it presents a large number of spines, which compromises its palatability and makes it difficult to manage (CAVALCANTI et al., 2008). These spines, although undesirable for animal feeding, it can guarantee to the plant greater drought resistance, because the spines help minimize stem temperature during the day (NEVES et al., 2010).

Crops are heavily influenced by long periods of drought, which results in major economic losses semiarid regions. So, studying the characteristics of forage palm varieties, as well as their properties, is necessary for the maintenance of productivity, once knowing the behavior of the species in certain situations, enabling us to conduct long-term planning for livestock production and feeding.

Soil and water salinity are some of the most important problems that influence the reduction of the growth and yield of cultivated plants, especially in arid and semi-arid regions (SOUSA et al., 2014), being necessary to adopt an adequate management strategy to minimize damages.

One of the consequences of salinity occurs when the dissolved salts contained in the irrigation water deposit at the base of the root system, which increase the osmotic potential, compromising the plant physiological processes. In this way the plants can present morphophysiological modifications to increase their tolerance to salinity, (HORIE; KARAHARA; KATSUHARA, 2012) results showed that all plants analyzed were affected by salinity, some in greater proportion and others in smaller ones.

Due to the misuse of water resources, the availability of good quality water for irrigation is increasingly restricted. Thus, the use of saline water becomes an alternative for cultivating tolerant plant species, using appropriate soil, water and plant

management practices (FREITAS et al., 2010).

Given the importance of forage palm, as well as its abundance and adaptation to the semi-arid region, it is necessary to search for alternatives to optimize its cultivation to increase livestock food support. This work evaluated the effects of different levels of salinity in irrigation water for two forage palm varieties ('elephant's ear and small) in the Brazilian Northeastern region.

4 MATERIAL AND METHODS

The experiment was conducted in an area belonging to the Federal Institute of Ceará – IFCE/*Campus* Sobral, from September/2017 to January/2018, located at the geographic coordinates 03º 41' 10" S and 40º 20' 59" W with an elevation of 70 m. The climate is classified according to Köppen as Aw', tropical semiarid with annual average rainfall of 854 mm and average temperature of 36 °C.

The plant used in the experiment was forage palm, with two varieties: small or sweet (*Nopaleaco chenillifera* Salm-Dick) and elephant ear (*Opuntia sp*), since they are the most produced by farmers. The rackets (cladodes) used in the experiment, from both varieties were provided by local farmers.

The substrates used were sand + bovine manure, in the ratio 1: 1 (v/v), homogenized and placed in pots with 25 liters capacity.

The water source was urban supply, with the addition of sodium chloride (NaCl), which was dissolved to prepare the solutions, the irrigation was done three times a week, based on the crop evapotranspiration (ETc), manually applied, with an applied volume of 250 ml per plant, measured in a graduated glass.

The experimental design was a completely randomized design, in the 5 x 2 factorial arrangement, with five salinity levels in irrigation water (0.0, 5.0, 10, 15, and 20 dS m^{-1}) and two palm varieties: small or sweet (*Nopaleaco chenillifera* Salm-Dick) and 'elephant ear' (*Opuntia* sp) with four replications.

To find the electrical conductivity of the saline solution (5.0, 10, 15 and 20 dSm-1) used in irrigation 01, equation 01 proposed by Richards (1954) was used:

$$C = ECs * 640 \quad (01)$$

Where:
C = Salt concentrations (mg L^{-1})
ECs = electrical conductivity of the solution (dS m^{-1})
640 = correction/adjustment factor.

After 90 days planting, a biometric evaluation of each plant was performed, with the following variables measured plant height (PH), circumference (CI), racket length (RL), cladodium thickness (CT), fresh mass (FM) and dry mass (DM).

A tape measure graduated in millimeter was used to determine the height, circumference and length of the racket. The cladodium thickness was measured by a pachymeter. To estimate the dry mass, the plants were placed in paper bags and dried in a forced air circulation at 65 ºC until obtaining a constant mass to obtain its value in a precision scale.

The data were submitted to the variance analysis – ANOVA, and the Tukey test at 1% of probability, using the SISVAR software (FERREIRA, 2011).

5 RESULTS AND DISCUSSION

Table 1 shows the variance analysis (ANOVA), with the values of the mean squares of the analyzed variables specified plant height (PH), circumference (CI), racket length (RL), cladodium thickness (CT), clododium number (CN), fresh matter (FM) and dry matter (DM) of the forage palm varieties as a function of the salinity of the

irrigation water.

Table 1. Summary of variance analysis of the mean squares of forage palm plants at 153 days after planting (DAP), Sobral, Ceará, Brazil.

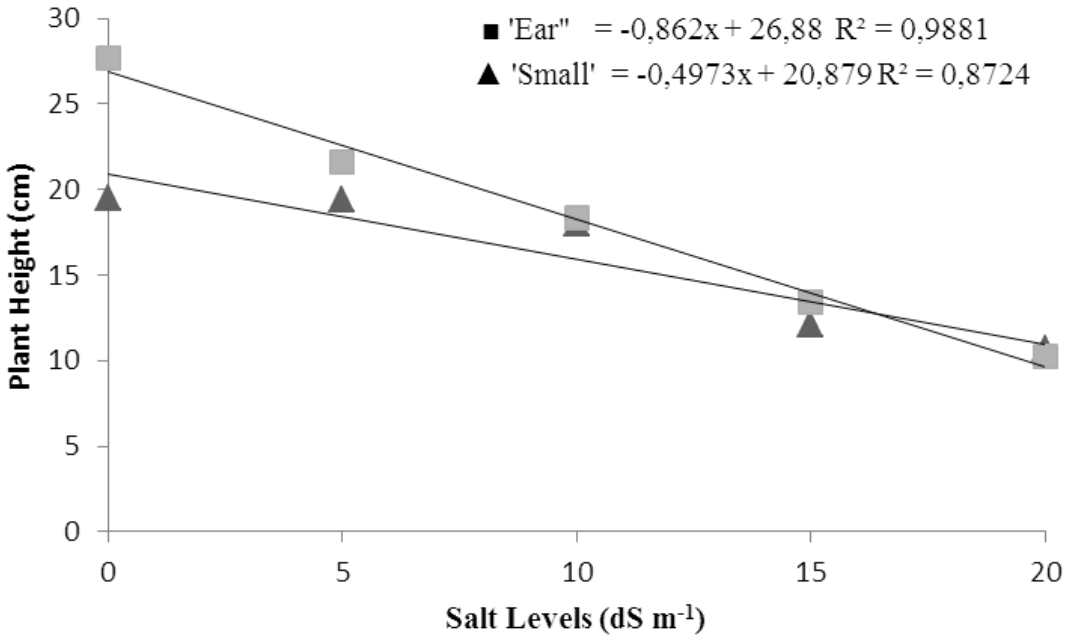
FV	GL	Mean Square						
		PH (cm)	CI (cm)	RL (cm)	CT (mm)	CN (mm)	FM (g)	DM (g)
Block	3	6.26^{ns}	6.04^{ns}	1.43^{ns}	1.60^{ns}	0.20^{ns}	2.44^{ns}	0.56^{ns}
Variety	1	55.4^{*}	42.29^{**}	116.21^{*}	0.62^{ns}	0.10^{ns}	900.8^{**}	11.40^{*}
Salinity	4	235.4^{*}	2.11^{**}	77.15^{**}	48.25^{*}	0.58^{ns}	1177.9^{*}	123.8^{*}
Sal. x Var.	4	23.5^{**}	922.1^{*}	1.60^{ns}	1.96^{*}	0.16^{ns}	13.9^{*}	1.91^{ns}
Error	2	3.90	8.54	0.80	0.58	0.22	4.54	0.88
CV (%)	-	11.2	7.7	8.7	15.4	33.8	6.2	13.7

CV – coefficient of variation; (*), (**) significant at a level of 99 and 95% confidence, respectively; (^{ns}) no significance.

Saline water from irrigation was significant at 5% level in all evaluated ratios, except for the cladode number in which no significant difference was observed. The interaction between varieties and salinity levels in irrigation water had a significant interaction, except for the racket length (RL), cladode number (CN) and dry matter (DM) variables.

The plant height of the two forage palm varieties showed linear decreasing trends with the increase of the salts in irrigation water, Figure 1.

Figure 1. Plant height of forage palm varieties as a function of water salinity levels. Sobral, 2018

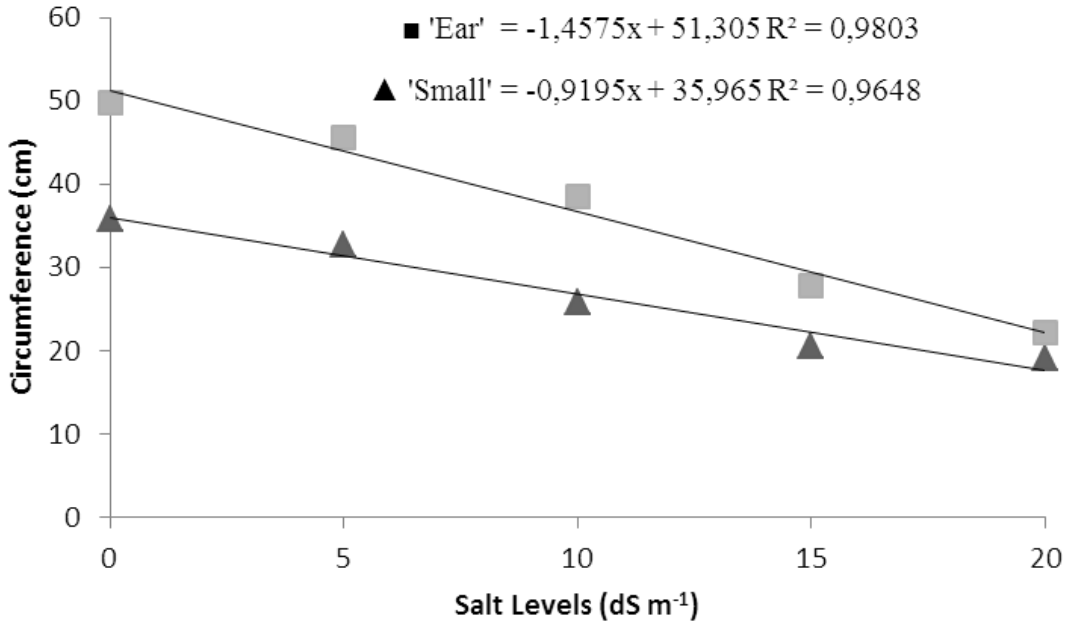


The 'elephant ear' variety was sensitive to the salinity of irrigation water, with a decrease in plant height of 36.5% difference between the levels of 0 dS m^{-1} and 20 dS m^{-1}, respectively, between the lowest and highest value of salinity. The 'small' variety showed a decrease in plant height of 60.5%.

A linear decreasing behavior for both varieties was observed with increasing level of irrigation water salinity (Figure 1). The results obtained in this work corroborate with results of Souza et al. (2018), when studying the initial development and tolerance of maxixe (*Cucumis anguria* L.) cultivars irrigated with saline water, resulting in a linear decrease for cultivar plant height (PH).

In Figure 2, when analyzing the effect of salinity levels on the circumference of the racket of the two forage palm varieties using regression analysis, it was verified that the best fit model was linear with decreasing trends with increase in the salinity level of irrigation water, with R^2 values of 0.98 and 0.96 for the 'ear' and 'small' varieties, respectively.

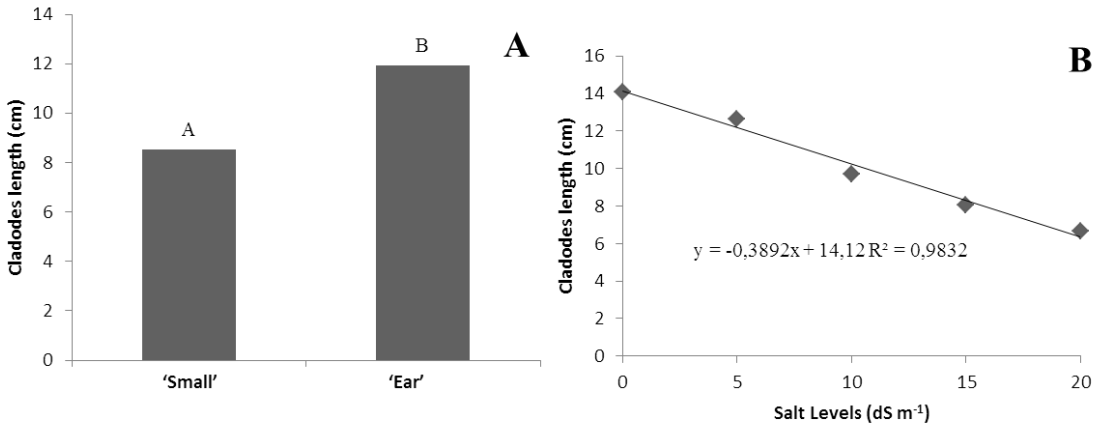
Figure 2. Cladode circumference of forage palm varieties as a function of irrigation water salinity levels. Sobral, 2018.



Studies of the relationship between the morphological and productive aspects of forage cactus clones showed that the linear correlations were those that best fit the contributions of racket length characteristics in response to the indirect effect of plant height, which are responsible for the plant's structure, thus, the height of the plant is directly related to the development of its cladodes, as analyzed by Silva et al. (2015). The development of the cladodes is directly correlated with its circumference.

Thus, it can be observed in Figure 3 that the influence of the addition of salt in the irrigation water presented similar results for the two varieties. Although there was no interaction between the variety versus salinity treatments, the negative effect of salinity was observed to increase water salt levels for variables racket length and number of cladodes, Figure 3A and 3B, respectively. As salt levels increase, the values of the analyzed variables drop.

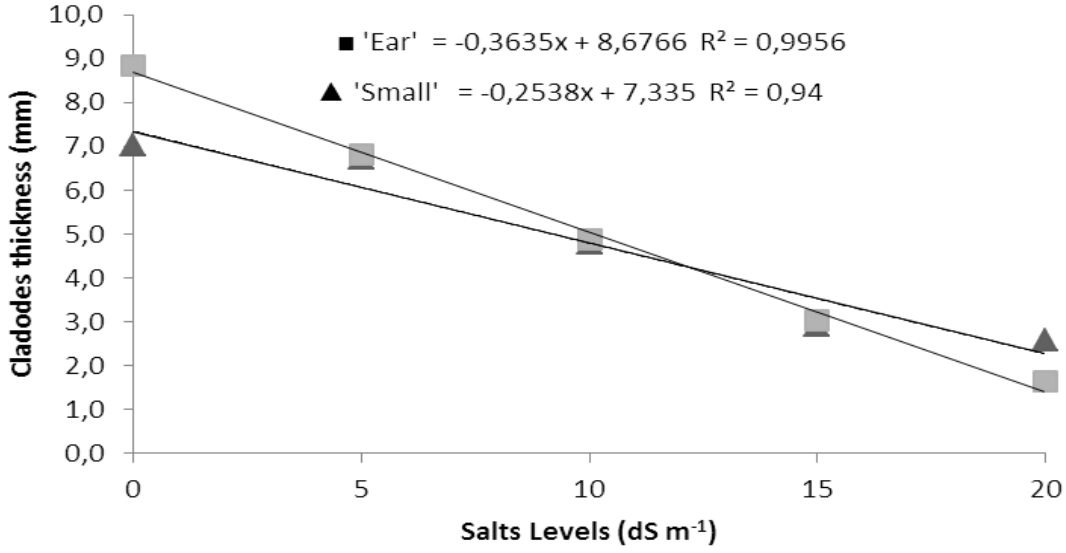
Figure 3. Cladode length of forage palm varieties as a function of irrigation water salinity levels: cladodes length of palm varieties (A) and cladodes length depending on the levels of salts (B). Sobral, 2018.



Similar results to this study were verified in observations made by Franco-Salazar and Véliz (2008), where the number of cladodes decreased significantly with higher NaCl concentration in irrigation water. In studies by Silva et al. (2014) with saline water in irrigation as alternative to forage production in the Northeastern Semiarid region of Brazil, it was observed that the effect of salinity on leaf area of sorghum decreased as the water's electrical conductivity increased, causing a significant decrease in crop yield.

In figure 4, salinity levels in irrigation water promoted a more severe decrease in cladodes thickness of the 'ear' variety, whereas the 'small' variety showed better results, even with smooth linear decreasing tendency for higher salinity levels. Silva (2018) also reported that the cladodes length and width decreased, demonstrating that continued use of saline water during the phenological cycle can affect the growth and development of the palm.

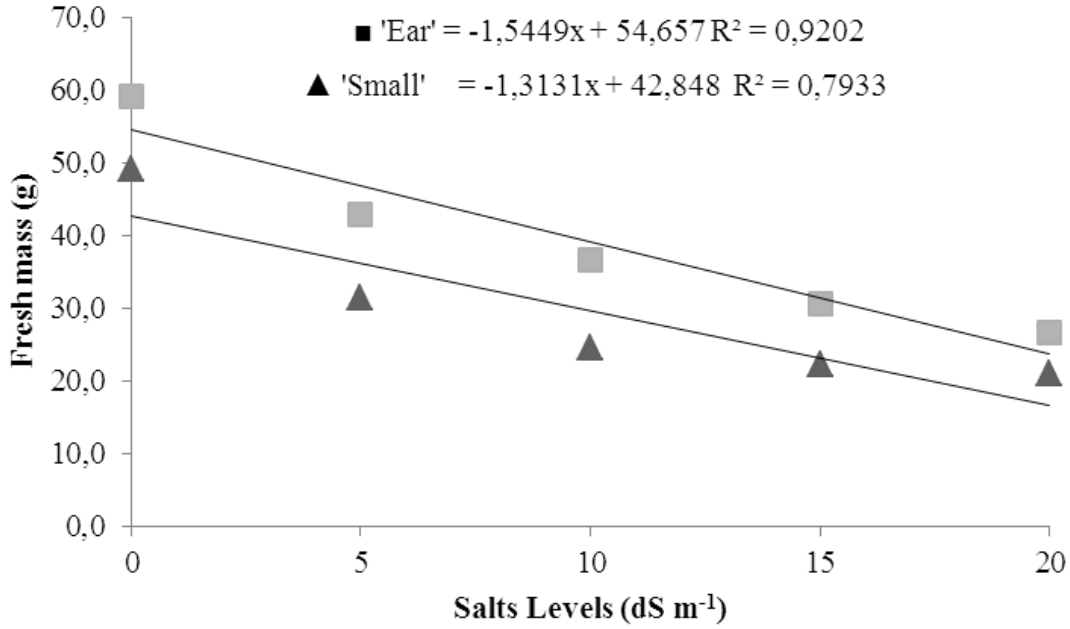
Figure 4. Cladode thickness of forage palm varieties as a function of irrigation water salinity levels. Sobral, 2018.



Higher salinity levels resulted in a lower cladode thickness, probably due to water stress and excessive salt levels in the soil and plants, causing cladodes dehydration. The thickness of the cladodes is related to the amount of water content, consequently, higher levels of NaCl and lower irrigation frequencies have led to smaller dimension.

The fresh mass of forage palm varieties was negatively influenced by increasing NaCl addition in the irrigation water. The two varieties had linear decreasing tendencies according to the increase in salinity. The 'ear' variety showed increasing values, at all levels of irrigation water salinity, having a higher weight of fresh mass, in relation to the 'small' variety (Figure 5). Working with melon cultivars under saline stress conditions, Aragão et al. (2009) observed a reduction in fresh and dry matter production, chlorophyl and leaf area for different melon cultivars with increasing soil salinity.

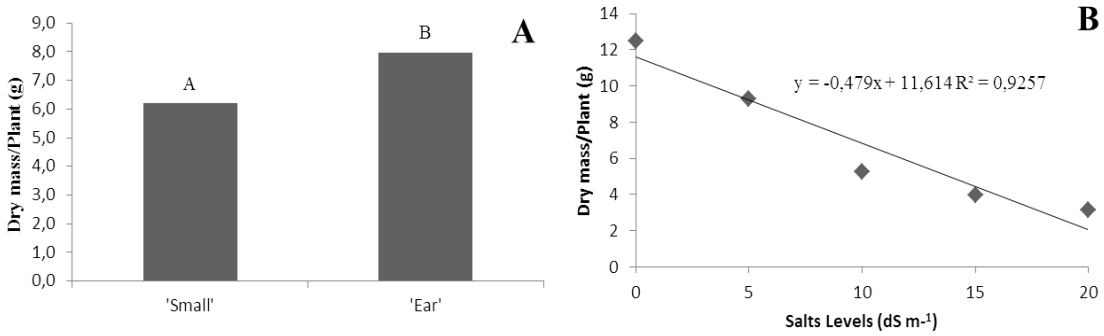
Figure 5. Fresh mass of forage palm varieties irrigated with different levels of saline water. Sobral, 2018.



Studying the initial development of *Eucalyptus platyphylla* plants submitted to salinity levels, Lopes, Lima and Klar (2012) observed different results to this work, regarding the fresh and dry mass of the roots of *Eucalyptus platyphylla* seedlings, revealing that there was no statistical difference between treatments submitted to different salinity levels.

Regarding the dry mass weight of forage palm varieties, there was a significant difference between them. The 'ear' presented higher values of dry mass (Figure 6A), meanwhile, the effect of salinity on the varieties caused a linear decrease with a value of R2 0.92. (Figure 6B), above 5 dS m^{-1} it was observed a significant decrease in dry mass, up to the level of 20 dS m^{-1} and above this a stabilization in decreasing of the dry mass occurred.

Figure 6. Dry mass of forage palm varieties irrigated with different levels of saline water: dry mass of palm varieties (A) and dry mass depending on the levels of salts (B). Sobral, 2018.



The dry mass reduction can be associated with the toxic effect caused by the increasing levels of NaCl in irrigation water, decreasing fresh mass and dry mass as a consequence. According to Araújo et al. (2010), the reduction of dry mass production is mainly associated with the toxic effect of ions such as Na+ and Cl- on net carbon fixation and photosynthesis production.

7 CONCLUSION

The 'elephant ear' variety showed to be more tolerant when submitted to increasing levels of NaCl in irrigation water.

The tested varieties decreased their growth, higher the salinity levels, the greater the negative effects on the aerial part of the forage palm varieties.

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